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C. P. Gillette
Iowa State College

The Plum Curculio and the Plum Gouger.

A Summer's Study of their Habits and Remedies.

C. P. GILLETTE.

These two arch enemies of the plum seem to vie with one another in their work of destruction in the Valley of the Mississippi.

The Plum Curculio, *Conotrachelus nenuphar*, has received much attention from entomologists and fruit growers for a great many years in this country and there remains little to be added to what is already known of its habits and life history. But the best remedies for these two plum insects, and especially for the gouger, have not yet been fully determined. During the last two or three years the arsenites have been much talked about as curculio remedies and a few careful experiments, at least, have been made to determine their value for this purpose.

Although the results obtained by experimenters differ widely, it is strongly to be hoped, perhaps I should say generally believed by those that have tried the experiments, that the arsenites will prove safe and effectual remedies to put into the hands of fruit-growers to be used against the curculio.

Prof. C. M. Weed of the Ohio Experiment Station, deserves much praise for the very careful and extensive experiments† conducted by him during the summers of 1888 and 1889 for the purpose of determining the effects of three times spraying early cherry trees with London purple to protect the fruit from the injuries of the plum curculio. The experiments for the two years gave almost identical results. In either case there was shown a reduction of a fraction over 75 per cent of wormy fruit on the treated trees as a result of the applications. But, as the cherries employed in the above experiment ripened in the midst of the egg-laying season of the curculio, it is not safe to conclude that as good results would have been obtained on plums or other late ripening fruit. In

†See Bulletins 4 and 6 of Ohio Experiment Station.

fact, those who have tried equally careful experiments on plums have not obtained as good results.*

In the summer of 1888 Prof. Osborn of the Iowa Agricultural College conducted some very careful experiments†† with London purple to prevent the injuries of the curculio and gouger to plums. These experiments showed a lessening of 22 per cent of the puncturing of the fruit and a lessening of 45 per cent of the grubs that actually infested the fruit. In these experiments gross results were given, the record of the two insects not being kept separate, so that we do not know what portion of the protection was due to lessened curculio attack and what to lessened gouger attack. In my own experiments detailed below, in which the records for the two insects were kept separate, I was not able to show as good results as those obtained by Prof. Osborn.

Very little attention seems to have been given to the plum gouger since the appearance of Walsh's First Illinois Report in 1867, and, so far as the writer is aware, there have been no carefully conducted experiments to determine the value of any method for the destruction of this particular insect. In parts of Iowa, at least, and probably in many other places in the Valley of the Mississippi, where the native plums are chiefly grown, this insect out-does the curculio in its injury to this fruit.

THE PLUM CURCULIO, *Conotrachelus nenuphar* (*Herbst*).

Habits and Life History.—Early in the spring of 1889 I began making observations to determine when the curculios should first appear upon the plum trees and later to determine when egg-laying should cease. Plum trees were jarred and the fruit examined at short intervals from April 25th to May 14th without finding either the beetles or their punctures. After the latter date the trees were not shaken but the fruit was almost daily examined for the purpose of finding the first marks of the little Turk. On May 25th the first punctures were found and on June 12th I estimated, after examining many plums, that the majority of the eggs then laid were still unhatched, and, as late as June 18th my notes say: "The examination of a number of crescents to-day shows that nearly one half of the punctures still contain unhatched eggs." After this last date it was noticed that the

*See Bull. 4 and 6 of the O. Exp. Sta. Experiments by Prof. C. M. Weed.
Miscellaneous Essays on Entomology. 1886, p. 33. Prof. S. A. Forbes.
U. S. Dep't of Agr. Rep., 1888, p. 72. Prof. H. Osborn.
Insect Life, v. 1, p. 193. Mr. G. C. Brackett.
††See U. S. Dep't of Agr. Rep. for 1888, p. 72.

eggs became rapidly more scarce. On June 19th the largest grubs examined were three sixteenths of an inch in length and on the 21st it was first noticed that the stung plums were beginning to fall. My notes for June 24th say: "Stung plums are rapidly falling now." At this time eggs were still found and the largest grubs were found to be nearly full grown. On June 26th one egg was found and another on the 28th of the same month. For several days after this search was made but no eggs were found which led me to think that egg-laying had ceased and I dismissed all thoughts of seeing more curculio eggs until another season. Imagine my surprise on July 22d when I observed that the fruit on a Forest Rose plum tree had many freshly made punctures of the curculio. In 21 cases the dried skin over the punctures was raised and the plump white eggs were seen while in as many other cases on the same tree the eggs were left undisturbed. The search was then extended to other trees and many newly laid eggs were found. On July 24th, twenty three punctured plums were taken from some small seedling trees. It was found on examination that these plums bore seventy-eight curculio marks, thirty unhatched eggs, seventeen short burrows of the larvæ and thirty shriveled egg shells. The largest of the larvæ found in these plums was not over one third grown.

On the same date, July 24th, seven curculios were taken from two Forest Rose plum trees and brought into the laboratory. In less than a half hour afterward four of the beetles were found pairing. One of these escaped and the other six were the same day inclosed in a large cheese-cloth sack which was drawn over a limb of a plum tree that was well loaded with fruit. In a day or two egg-laying began and was continued as late as the 10th of August, at least. Outside of this sack eggs were found upon different trees as late as August 22d.

On the 22d of July mature beetles were found in a breeding cage where I had confined early stung plums. This appearance of the bred beetles so nearly coincided with the sudden appearance of so many fresh punctures and eggs upon the fruit that I was led to strongly suspect a partial second brood of considerable size. For the purpose of obtaining farther evidence upon this point a number of the earliest appearing beetles in my breeding cages were inclosed in a large cheese-cloth sack which was pulled over a well loaded limb of a plum tree. The beetles remained contentedly in the sack for several weeks feeding freely on the plums but no eggs

were laid. This, and the farther fact that the insect was found in the larval state in my breeding cages as late as September 26th, lead me to conclude that there is probably not even a partial second brood of the plum curculio in central Iowa. These conclusions are in accord with those of Dr. Riley as stated in his III Mo. Report, p. 39.

Notes on the Late Part of the Brood.

The following notes upon the late part of the brood I am sure will be of interest.

On the 23d of July 32 Yellow Mira Belle plums bearing curculio marks were gathered and placed on earth in a jar. On August 17th the first mature beetle was seen crawling about and on September 24th there were 21 beetles and no larvæ or pupæ.

Three De Soto plums, each containing a fresh puncture and an unhatched egg, were picked from a tree and placed on earth in a glass jar August 14th. On September 24th two lively mature beetles which had not yet come to the surface were found by breaking up the earth in the jar.

On July 16th I received 20 plum curiculios from Mr. N. K. Fluke of Davenport, Iowa. The insects were obtained by jarring Duchess apple trees July 10th. I examined these beetles for eggs with the following results: 14 with no eggs, 1 with 1 egg, 3 with 2 eggs each, 1 with 3 eggs and one with 6 eggs. A total of sixteen eggs. How many of the beetles were males I do not know.

Abundance of the Curculios.—The curculio was not very abundant last summer on the College grounds. Twenty untreated plum trees bearing an aggregate of 12,564 plums had only 1,045, or a little over 8 per cent of their number, injured by this insect. Judging from reports they were much worse than this in other parts of the state.

Partial to Tame Varieties.—A record of the fruit injured by the plum curculio and by the plum gouger on the few trees of tame varieties and many trees of native varieties on the College grounds was kept for the purpose of determining whether or not this insect is partial to tame or wild fruit. The figures given in the following tables speak for themselves in regard to this matter.

TAME VARIETIES.

VARIETIES.	Total Plums.	Injured by Curculio.	Injured by Gouger.	Per cent injured by Curculio.	Per cent injured by Gouger.
Yellow Mira Belle	515	339	0	.66	0
Black Prune	136	19	9	.14	.066
Bier	73	23	0	.315	0
Early Red	149	28	10	.19	.064
Totals	873	409	19	.468	.022

NATIVE VARIETIES.

VARIETIES.	Total Plums.	Injured by Curculio.	Injured by Gouger.	Per cent injured by Curculio.	Per cent injured by Gouger.
Miner (five trees)	6,476	163	1,865	.025	.288
Wolf (three trees)	620	107	372	.173	.60
Chickasaw (one tree)	370	58	100	.157	.27
Forest Rose (one tree)	1,549	211	58	.136	.037
Native Seedling (one tree)	193	16	111	.083	.575
Native Seedling (one tree)	271	70	210	.258	.775
Native Seedling (one tree)	212	11	33	.052	.156
Totals	9,691	636	2,749	.066	.284

From the above tables it will be seen that the curculio injured 66 per cent of the Yellow Mira Belle and an average of 46.8 per cent of all the plums of the tame varieties while the least injury done to any of the tame varieties, the Black Prune, was 14 per cent. Among the native varieties the highest percentage of injury was 25.8 per cent and the average was only 6.6 per cent.

These tables certainly indicate that the plum curculio has a decided preference for the domesticated varieties.

I will here state that several small trees of the Japanese Plum, *Prunus simoni*, carried their fruit to maturity without in any case receiving a mark from the plum curculio or the plum gouger. Prof. Budd tells me that he has never known

this fruit to be injured by the curculio. The fruit is not, I believe, a plum.

The Curculio Infesting Apples.—Although it has been repeatedly proven by entomologists that the curculio can and does come to maturity in apples, there are many fruit growers that do not know this to be the case and the following account of its work on this fruit may be of interest.

Mr. N. K. Fluke, a prominent Horticulturist of Davenport, Iowa, wrote me under date of June 29, 1889, as follows:

"Mr C. P. GILLETTE, *Dear Sir:*— * * * In going over my 60 Duchess apple trees this spring seventeen times with a sheet from the 16th of May to the 12th of June I caught about 4,000 curculios, nineteen twentieths of which were the plum curculio and the remainder the apple curculio. * * * * I should say that the plum curculio does more injury to my Duchess apples than to my plums."

From another letter by Mr. Fluke dated July 12th I extract the following:

"I took the sheet day before yesterday and went over a few Duchess trees and caught about twenty plum curculios, as I suppose them to be. As I said before, of upwards of 4,000 curculios that I have caught off the Duchess trees this summer, I do not think that I noticed over a half dozen apple curculios. You will find that nearly every egg deposited in a Duchess hatches and the worm dies in the apple, at least, I have never been able to find the larvæ more than half grown or any place of exit made in the hundreds of apples examined."

"For the purpose of determining whether I am correct or not I have gathered a small basket of recently fallen fruit which I send you by express to see whether you can rear a curculio from them. Let me hear from you as to your success in raising the beetles.

Yours in the interest of Horticulture,

N. K. FLUKE."

The basket containing 56 immature Duchess apples came duly to hand. Upon these apples I counted 180 punctures that I judged to be curculio marks. In puncturing the apple the curculio usually does not make its characteristic crescent but only a broad puncture or slit running obliquely into the flesh of the fruit. Such punctures as these are not very uncommon on plums.

The apples were placed upon moist earth in a box and covered with cheese-cloth. On August 21st the contents of the box was carefully examined and 11 fully matured beetles, 49 immature beetles and 21 pupæ of the curculio were found, a total of 81. This is fully as many curculios, I think, as would often be reared from an equal number of punctures upon plums.

Curculio-proof Plums.—Much has been said and written during the past few years about curculio-proof plums and the reasons why certain varieties are not infested. The Wier

theory,*—that the curculio larvæ very rarely develop in the wild varieties and that the beetles are especially attracted to these varieties for oviposition and, hence, that a few native trees in a plum orchard will keep the curculios in check and protect other trees from injury—has, I think, been fully exploded by Dr. Riley* and others. My own close observations the past summer on five tame varieties and a large number of natives indicate, as shown in the foregoing tables, that a much larger percentage of the fruit of the former is injured by this insect than of the latter. In all cases I found the larvæ developing as well in the native as in the tame varieties.

Aside from my own observations I give the following replies to questions sent to prominent horticulturists.

To the request: "Name one or more varieties of plums grown by yourself that are worst attacked by the curculio." I received the following replies:

"Miner." A. F. Collman, Corning, Iowa.

"Forest Garden and natives generally." W. H. Guilford, Dubuque, Iowa.

"All the older Domestica varieties alike." T. T. Lyon, S. Haven, Michigan.

"Forest Garden, Weaver, Wild Goose, Damison and Imperial Gage." N. K. Fluke, Davenport, Iowa.

"Wild Goose, Spoon River and native Sloe." J. Miller, Oakville, Iowa.

To the request: "Name one or more varieties least attacked by the curculio," I got the following replies from the same persons.

"Wild Goose" A. F. C.

"Forest Rose and Weaver." W. H. G., Dubuque, Iowa.

"The Americana class." T. T. L. South, Haven, Mich.

"Little difference. In Rockford and DeSoto the eggs are expelled or fail to develop." N. K. F., Davenport, Iowa.

"Gen. Grant and Chicasa varieties." J. M., Oakville, Ia.

To the question: "Are the native varieties worse attacked than the tame varieties?" I received the following replies:

"Yes." (A. T. C.) "No." (W. H. G.) "Less." (T. T. L.) "No." (N. K. F.) "No." (H. A. Terry.)

To the question: "Are the rapid growing varieties, those that grow quickly to a large size, more or less attacked by the curculio than others?" I received the following:

"Less (?)." (A. T. C.) "More." (W. H. G.) "I know no difference," (T. T. L.) "I don't see much difference." (N. K. F.) "Probably less." (H. A. T.)

*See Bull. 14 U. S. Dep't of Agr., Div. Ent., p. 49.
Ibid. p. 50.
See Proc. Am. Pom. Soc. 1889, p. 35.

The variety of replies as given above is sufficient to make us very slow to take any man's word when he claims to have curculio proof plums. A few varities that happen to be in a favorable location in one orchard, or for other reasons are not noticibly injured by the curculio, may be badly infested in another orchard. *Those that have studied this subject most thoroughly and carefully know no curculio proof plums.*

The question in regard to the large quick growing varieties was asked because I had been informed by a prominent horticulturist that it was not the native varieties but the succulent quick growing varieties that escaped injury most. As bearing upon this point I gathered plums of the largest most rapid growing varieties and of the slowest growing varieties that could be found on the College grounds on July 29th of last year. These plums were carefully weighed and evaporated to dryness and the dry matter weighed for me by the Station Chemist, Prof. G. E. Patrick. From these weights I figured the percentages of moisture as given in the following table.

TABLE SHOWING PERCENTAGES OF MOISTURE IN GREEN PLUMS.

NAME OF PLUM.	Weight of Plums.	Weight of Dry Matter.	Dry Matter, Per Cent.	Water, Per Cent.
Early Red	12,279 grms.	2,152 grms.	.1752	.8248
Early Red	10,463 grms.	2,066 grms.	.1974	.8026
Prunus Simoni	15,176 grms.	2,191 grms.	.1444	.8556
Forest Rose	11,881 grms.	2,167 grms.	.1824	.8176
Maquoketa	11,101 grms.	2,024 grms.	.1823	.8177
Rollingstone	9,258 grms.	2,292 grms.	.2475	.7525

The first three varieties given in the table represent the large quick growing plums while the last two grew slowly and did not attain a large size.

The Prunus Simoni fruit seems to have been most succulent of those examined and, as stated before, this fruit was not at all injured by insects here last summer. This fact, however, is probably due, not to the succulence of this fruit but to its peculiar flavor. The Rollingstone, the slowest growing and the smallest of the plums examined, should, according to the above theory, have suffered most from curculio attack. The facts are that this plum suffered about the least of any of the native plums on the College grounds last

summer. The other large varieties, the Early Red (or White Nicholas) and the Forest Rose, were much worse attacked than the small varieties.

I must say from my own careful study of this subject and from what I can learn from questioning fruit growers that the large quick growing varieties are rather more subject to attack than the smaller, firmer meated, inferior varieties.

Curculio Parasite. The common curculio parasite, *Sigalphus curculionis*, was quite abundant in this vicinity last summer. This parasite is a small slender four winged fly about .14(1-7) of an inch in length, black in color and with an ovipositor nearly as long as the entire insect protruding from the under side of the abdomen.

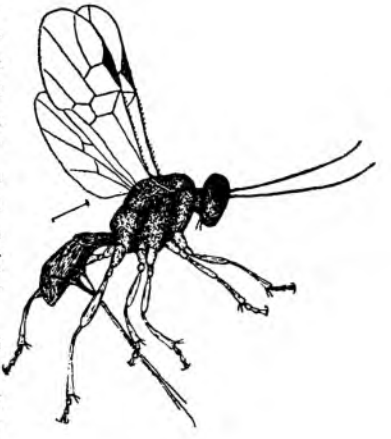

Fig. 1.—*Sigalphus curculionis*, copied from Riley.

The variety *rufus*, which was four times as abundant as *curculionis* (Fig 1) in my breeding cages last summer, is distinctly larger and more robust than the latter. The head, thorax, and basal portion of the first abdominal segment are rufous and the ovipositor is much longer in proportion to the length of the insect. Dr. Riley's description† of this insect (var. rufus) gives twenty-seven as the number of joints to the antenæ and no mention is made of any variation. Three females of the black form reared by myself and two males loaned me by Prof. Osborn have joints to their antennæ as follows: One male with twenty-nine joints and one with thirty, and one female with twenty-eight joints and two with thirty joints each. Of eleven females of the variety rufus in my collection, in five cases the antennæ are thirty-two jointed, in four cases thirty-one jointed and in two cases thirty jointed.

THE PLUM GOUGER, *Coccotorus prunicida** Walsh.

The following is a bibliography of the more important articles on this insect.

*The observations of Prof. L. Bruner in Neb. make it quite certain that *prunicida* Walsh, is a good species.
See Insect Life, v. II. p. 259.
†See Riley's III Mo. Rep. p. 27.

1866. WALSH. BENJ. D. *Anthonomus prunicida.* Practical Ent., v. 1, p. 79. Popular description. Life habits.

1867. WALSH, BENJ. D. *Anthonomus prunicida.* 1st. Rep. as Ent. of the State of Ill., p. 72. Life habits and remedies. Ibid, p. 15. Larva distinguished from that of the Grape Curculio.

1869. WALSH, BENJ. D. *Anthonomus prunicida.* Am. Ent., v. 1, p. 93. Habits of the larva.

1870. RILEY, C. V. *Anthonomus prunicida.* III Rep. as Ent. of the State of Mo., p. 39. Character, distribution, food and natural history.

1870. LE BARON, WM. *Anthonomus prunicida.* 1st Rep. as Ent. of the State of Ill., p. 94. Preparation of the exit from the pit.

1883. SAUNDERS, WM. *Coccotorus scutellaris.* Insects Inj. to Fruit p. 187. Life habits and remedy.

1888. BRUNER, L. *Coccotorus scutellaris.* Insect Life, v. I, p. 89. Mode of oviposition. Repeated in Insect Life, II, p. 259 (C. prunicida) and in U. S. Dep't. of Agr. Rep. 1888, p. 139.

1888. BRUNER, L. *Coccotorus scutellaris.* Ann. Rep. of Neb. St. Brd. of Agr. 1888, p. 124. Method of oviposition, life history, food habits.

HABITS AND LIFE HISTORY.

The Plum Gouger (Fig 2, E) is a Western insect and is rarely if ever found farther east than Lake Michigan.

This insect in its mature state is a beetle, somewhat resembling, and frequently mistaken for the plum curculio. It varies from 7-32 to 8-32 of an inch in length. The wing covers are leaden gray in color and are more or less sprinkled with small black and brown spots. The head and thorax are ochre-yellow in color and the snout and legs are reddish brown and are covered with short hairs. In fresh specimens there is a yellowish brown median line along the back on the borders of the wing covers of the same color as the thorax. The rostrum or snout is slender, very slightly curved and about as long as the head and thorax, or about 1-12 of an inch.

Spring Appearance.—The beetle appears in the spring much earlier than the curculio. They feed on the buds and flowers* of the plum tree, pair, and are ready to begin

*Since writing the above I have found by bringing the beeties into the laboratory and keeping them on fresh plum twigs that, since the flowers began to open, they feed entirely upon the ovaries of the buds and blossoms which they reach by puncturing the calyx. Six beetles in 24 hours punctured the calyces and ate the ovaries of 65 buds and blossoms.

their work of egg-laying as soon as the plums are ready for them.

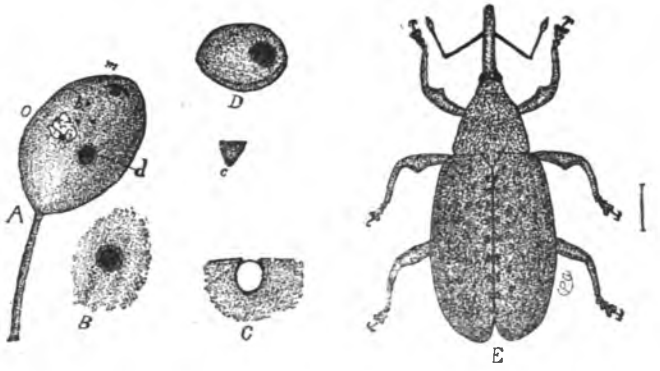

FIG. 2.—PLUM GOUGER, *Coccotorus prunicida.*

A—Plum showing punctures of the gouger at b, crescent of the curculio at m, exit of gouger at d, and a mass of gum at o.

B—A puncture showing the black exposed portion of the egg. Much enlarged.

C—A vertical section through the puncture showing a freshly deposited egg:—c, an egg-pocket a few days after the egg has been deposited, removed from the fruit.

D—A plum pit showing exit.

E—The mature insect, much enlarged.

Beetles were taken by me last spring from plum trees at this place on the 16th of April, fully one week before the trees were in bloom. Nearly as soon as the little plums were formed it was noticed that the gougers had begun to feed upon them. At just what date egg-laying began was not determined. On the 14th of June the females were in the midst of their work of oviposition and unhatched eggs were seen as late as June 29th.

Egg-Laying.—The entire process of egg-laying, as observed by the writer, was as follows. The female first gnawed a shallow hole in the plum just large enough to receive the egg. Then turning herself about and applying the tip of her abdomen to the little cavity thus made she dropped an egg in it and walked deliberately away without ever turning about to see whether or not the operation had been satisfactorily performed. About five minutes were occupied in making the excavation and not more than one minute was taken to lay the egg. This beetle was caught and on dissection eight well developed eggs were found in the ovaries. The egg which I saw the female deposit was removed from the plum an hour later and carefully examined under the microscope. It was yellowish white in color, had no external markings, and measured 1-35 of an inch in length by 1-40 of an inch in

breadth. A cross section of the little egg cavity with the egg in it is shown enlarged at Fig. 2. C.

By comparing this egg with those freshly taken from the ovaries of the female it was evident that it had absorbed some of the juice of the plum and become somewhat enlarged since being deposited as the fresh eggs were some smaller and more elongate. The illustration shows that the egg when examined had swollen so as to be too large to pass through the orifice in the skin of the plum. The plum in healing forms a tough pocket or cup (c) in the shape of an inverted cone which may be easily turned out with the egg in it. The egg itself on being exposed to the light at the opening, where it is almost flush with the surface, changes in a short time to a shiny jet black color (Fig. 2, B.)

The wounds (Fig. 2, b.) in the fruit produced by this insect, whether for food or the laying of eggs, always appear as little black specks. They extend directly into the flesh of the plum and are not easily mistaken for the subcutaneous slit and characteristic crescent (Fig. 2, m.) of the curculio. These punctures sometimes cause the exudation of a large quantity of gum which not infrequently crowds out the little cup with its egg.

The little grub as soon as it hatches eats its way directly to the pit of the plum and on reaching it always bores directly into it, and never tunnels about on the surface of the pit as does the plum curculio larva. On examining a large number of plums June 14, it was found that in a few cases the eggs had hatched and the larvæ had made their way to the pits, but in the great majority of cases the eggs were unhatched. The little grubs are very slow in getting through the flesh and especially the pit of the plum. My notes for June 24 say: "The gougers in most cases are only just reaching the pits." At this date the curculios were much farther advanced and the infested plums were fast falling.

On cutting open many pits June 25, several cases were noticed where the head of the grub could be seen projecting through the inner wall, but in no case had one entered the meat of the pit. The first grub was found entirely within the meat of the pit on July 3. The grubs seem to be a great while getting free from the pit after getting their heads through. I think the time will average, at least, a week. July 13 many larvæ had not fully entered the pit. July 29 I found on opening 21 plums from a seedling tree that in 18 cases the larvæ were full grown and had their exits partially or entirely made through the pits, and in three cases they

were changed to pupæ. In one of these plums two larvæ were found. The food was all devoured and one was only about half grown and probably would not mature. The larva when it becomes full grown gnaws an opening in the pit (Fig. 2, D.) and then changes to the pupa or resting stage and remains within the pit until it changes to the mature beetle. The beetle then makes its escape by gnawing a tunnel through the flesh of the plum, beginning at the opening instinctively made by the larva. On August 12 a number of DeSoto plums were opened and the gougers were found to be mostly pupæ and partially developed beetles. In two or three cases the beetles had matured sufficiently to be able to walk away on being released, but none had yet escaped from the fruit. On August 14 a beetle appeared in my breeding cage where I had enclosed early stung plums and in the afternoon of the same day I found out-of-doors on a DeSoto tree a single plum from which a gouger had escaped. In a very few days the plums containing the exits of the gougers were abundant everywhere, and by the fifth of September all but a few stragglers had left the plums. August 19 DeSoto plums bearing 677 gouger marks were gathered and put in a box. From this box were taken on the 21st of August, 92 beetles, on the 24th of August, 19 more, and on the 28th of August, eight more. So the great majority of beetles escaped last summer from the DeSoto plums between August 15 and 21. Beetles thus reared were placed in breeding cages and kept supplied with plums, plum leaves and apples for a long time afterward but I could not induce them to take any food, and I came to the conclusion that the hearty meals eaten while gnawing out from the plums were sufficient to last the beetles until the next spring. Neither did the beetles linger on the trees after leaving the plums as I found by repeated jarring of the trees that I could but rarely obtain one. I also found that rubbish put beneath the trees would not collect them, and it is my opinion that they went at once in search of suitable quarters in which to spend the winter.

Extent of Attack.—The gougers, unlike the curculios, showed a decided preference for native varieties. The five tame varieties, aside from Prunus simoni, which was exempt from insect attack, had, as shown in the foregoing table, 2.2 per cent. of their fruit punctured by the gouger during the summer against an average of 27 per cent. on the native varieties as determined by carefully counting and examining over 10,000 plums on 11 different trees between August 20 and September 6.

As to the proportion of gougers in the fruit to the number of mature beetles developed I can not do better than give the counts made on a native tree September 6 when nearly all of the beetles had escaped. There were on the tree and ground 2,541 plums, 795 of which bore 894 gouger marks and the number of exits was 234. If this tree was a fair test, and I judge from partial counts on many other trees that it was, it indicates that 26 out of every 100 gouger marks will produce mature insects.

Remedy.—The plums infested by the gouger do not, so far as my observations have gone, ripen or fall prematurely, and all stung fruit that falls before the 20th of June will not mature the perfect insect. So, gathering the fruit as it falls, will be of no account as a remedy. There is one remedy, aside from jarring and collecting the beetles, that seems to me to be a very practical one, and that is to gather and destroy all stung fruit as soon as possible after July 1 and before August 10. This might seem, at first thought, to be too laborious a task, but it should be remembered that if all the trees in a district could be once thoroughly gone over with in this manner it would mean practical extermination of the gougers in that locality for years, for at this time every gouger in the country is imprisoned in the plums.

London Purple as a Remedy for the Plum Curculio and the Plum Gouger.

As no carefully conducted experiments have ever been made for the purpose of determining the value of the arsenites for the destruction of the gouger, and as it is not yet sufficiently proven that these poisons can be depended upon to destroy the curculio, I thought it advisable last spring to test the effect of London Purple on these pests. For that purpose I chose five native trees (one Rollingstone, one De Soto, one Maquoketa, one Speer and one seedling) to be treated, and five other natives (all Miners) of about the same age and size as checks. The check trees were about fifty rods distant from those sprayed. I could have taken trees for checks in the immediate vicinity of the sprayed lot, and of the same varieties but in taking the Miners I thought I was choosing the lesser of two evils. It is impossible to know what effect the difference in location and varieties might have had on the severity of the attack. We know that both of these beeetles, especially the gouger, are quite active and pass freely from tree to tree. So that when a part of the trees in an orchard are poisoned

and a part not it is in all probability true that many of the beetles that are poisoned upon the treated trees would lay a part of their eggs on the untreated trees, and, conversely, beetles feeding upon untreated trees would lay a portion, at least, of their eggs in the fruit of the treated trees. As a result of these conditions the treated trees would have more stung fruit than if all the trees were treated, and the check trees would have less fruit stung than if none of the trees near them had been sprayed. How considerable the error from these sources would be none is able to say, but that such an error must always exist can not be doubted. There is another possible cause of error when sprayed and check trees are near each other, especially where several sprayings take place, and that is to drive the beetles from the sprayed trees and to cause them to accumulate unduly on unsprayed trees. In fact the unavoidable sources of error in an experiment of this sort are so many that accurate results can only be reached by generalizing from a large number of carefully conducted experiments extending through several years. It is the opinion of the writer that the most accurate results would be reached by having the checks, which should be of the same or closely related varieties, well separated from the sprayed trees, care being taken that they are as nearly as possible under the same conditions. For this reason I chose my checks as above mentioned.

Application of the Poison.

The poison used was London purple and it was applied by means of a Nixon Barrel Machine and No. 3 nozzle. A strong man worked the pump and the dense floating spray emanating from the nozzle was directed to all parts of the tree until the leaves began to drip. The application, it seemed to me, could not have been more perfect. Two applications were made. May 4, twenty-three plum trees were treated with London purple in water in the proportion of one pound to 120 gallons. Twenty gallons were used in making the application. A flour paste in the proportion of ½ ounce of flour to a gallon of the mixture was added before applying the mixture. Most of the trees were in full bloom but a few of them had already lost most of their flowers. On May 11 the application was repeated in the same strength. At this time the more forward trees were loaded with small plums to which the dried calyces were still clinging while the more backward trees had only just lost their flowers. Too much

poison was used in these applications as the leaves were quite badly burned.

All plums that fell after May 25 were gathered at short intervals and closely inspected for curculio or gouger injuries up to the time of the ripening of the fruit, when all the plums still on the trees were examined to complete the record.

The five treated trees were given the first five letters of the alphabet and I give below their record.

RECORD OF CURCULIO AND GOUGER INJURIES TO FRUIT OF TREATED TREES.

Trees	Total Plums	Gouged	Cur. Inj.	Per cent. Gouged	Per cent. Inj. by Cur.	Variety
A	1,187	726	54	61.16	4.5	Speer.
B	6,720	1,203	5	18.00	.07	Maquoketa.
C	3,106	1,112	57	36.00	1.8	Seedling.
D	2,711	576	31	21.24	1.14	Rollingst'n.
E	856	274	56	32.00	6.5	DeSoto.
Total	14,580	3,891	203	26.7	1.4	

The five checks were given numerals 1–5, and the following is their record.

RECORD ON CURCULIO AND GOUGER INJURIES TO FRUIT OF UNTREATED TREES.

Trees	Total Plums	Gouged	Cur. Inj.	Per cent. Gouged	Per cent. Inj. by Cur.	Variety
1	2,	686	50	25	1.8	Miner.
2	1,126	400	44	32.6	3.6	"
3	667	138	33	20	5	"
4	975	334	16	34.2	1.6	"
5	954	307	20	32.2	2.1	"
Total	6,476	1,865	163	27.3	2.5	

These two records show a difference of 1.1 per cent. in the amount of fruit injured by the curculio and a difference of .6 per cent. in the amount of fruit injured by the gouger in

favor of the treated trees. As 27.3 per cent of the fruit on the untreated trees was injured by the gouger there was indicated a saving of 2.2 per cent of the fruit that would have been injured by this insect in the absence of any treatment.

In case of the curculio the indicated saving of fruit that would have been injured in the absence of treatment was 44 per cent, or twenty times as great as in the case of the gouger.

Probably better results would have been obtained in case of the curculio if each application had been made ten days later, or if a third application had been made ten days later than the second. The applications were made early because of the presence of the gouger on which it was especially desired to get results, and the trees were too much injured by the first two applications to admit of a third.

I also kept a record of plums growing on a number of native trees on another part of the grounds from 20 to 50 rods distant from the treated trees. These were not thought good as checks as they were of many sizes and varieties, some of them mere bushes, and they were mostly grown in hedge rows. I give this record below but think it of little value in showing the protection given by the use of the London purple.

RECORD OF CURCULIO AND GOUGER INJURIES TO A MISCELLANEOUS LOT OF TREES.

Trees	Total	Gouged	Cur. Inj.	Per cent Gouged	Per cent. Inj. by Cur.
Wolf (3 small trees)	620	372	107	60	17.3
Chippewa (1 small tree)	370	100	58	27	16
Forest Rose (1 large tree)	1549	56	171	3.6	11
Seedling (small native)	193	111	16	60	8
" " "	212	33	11	15	5
" " "	271	201	70	74	25
Totals.	3215	873	435	27.2	13.5

It is remarkable that the plum injuries in this group resulting from the attack of the gouger varies but 1-10 of 1 per cent. from that in the previous untreated group while the percentage of curculio injury is over five times as great. If this group of trees could be taken as checks we should get

an indicated saving of ninety per cent. from curculio injuries on the treated lot.

It was a noticable fact that the small, low spreading plum trees had their fruit worse attacked by the curculio than those of larger growth. The Forest Rose tree in the above lot was an exception. This tree and five others of the same variety had their fruit much worse attacked by the curculio last summer than did any other large trees of native varieties grown on the College grounds.

THE GOUGER PARASITE, *Sigalphus canadensis.*

Three specimens of the above named Hymenopterous insect were taken within the pits of plums infested by the gouger last August. The species was determined for me through the kindness of Dr. Riley, to whom a specimen was sent.

This insect is scarcely distinguishable from the black variety of the curculio parasite, *S. curculionis*, (Fig. 1) except by its somewhat larger size and its longer ovipositor. There is hardly a doubt but what the eggs of this insect are placed within the pit by thrusting the long ovipositor through the flesh of the plum so as to strike the opening prepared by the mature larva of the gouger for the future escape of the beetle. At least, in the cases of parasitism examined by me the larval gougers had in every instance made the exit in the pit before succumbing to the attack of the parasite. The parasite on coming to maturity and finding an opening in the pit easily gnaws its way out through the flesh of the plum. The opening thus made is much smaller than those made by the beetles in making their escape, and on examining many plums last August I frequently came across these small openings, that were in all probability made by this beneficial insect. I believe this is the first mention of a parasite upon the plum gouger, and it does seem that a grub incased within the hard pit of a plum would be safely hidden from insect enemies, but such is not the case.

CONCLUSIONS.

The following conclusions seem to be fairly drawn from the experiments and observations of the past summer:

1. The gouger appears upon the trees much earlier in the spring than does the curculio.

2. The gouger is much more injurious than the curculio to native plums on the grounds of the Iowa Agricultural College.

3. The gouger very much prefers the native to the domestic varieties.

4. The examination of over 24,000 native plums, from not less than 18 different trees of many varieties, showed a little over 27 per cent of their fruit to be injured by the gouger.

5. The gougers take no food in the fall after emerging from the plums.

6. The gouger has, at least, one parasite that preys upon it while in the pupa state. The parasite is *Sigalphus canadensis*.

7. The season's experiments indicate that London purple, as recommended for the destruction of the curculio, is of little value for the destruction of the gouger.

8. The gouger is not able to come to maturity in fruit that falls from the trees before the middle of July.

9. Fruit infested by the gouger does not ripen or fall prematurely.

10. About 26 per cent of the punctures of the gouger result in the production of a beetle.

11. Jarring the trees and collecting the beetles and gathing stung fruit from the trees before the first of August are the best remedies at present known for the gouger.

12. The curculio prefers the domesticated to the native varieties of plums.

13. When eggs are deposited in native plums, the curculio develops as well in them as in the domestic varieties.

14. Native varieties are not a protection to domestic varieties. The fact that two Yellow Mira Belle trees growing in the immediate vicinity of many natives had 66 per cent of their plums destroyed by the curculio, while the natives had less than 10 per cent of their fruit punctured, is sufficient proof of this.

15. That succulent, quick growing plums are not less attacked than slow growing varieties.

16. The curculio develops readily in the Duchess apple.

17. The curculio is not double brooded in Iowa, but the eggs deposited late in July and August are from belated females.

18. The two applications of London purple in water, although not made at the times best suited to destroy the curculio, apparently gave a protection of 44 per cent against the ravages of this insect.

19. London purple in water in proportion of one pound to 120 gallons is much too tsrong a mixture for plum trees. One half this strength is as strong a mixture as should be used.